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# VOICE ERGONOMICS FOR PHYSIOTHERAPY STUDENTS – LECTURE MATERIAL

Degree Programme in Physiotherapy
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# VOICE ERGONOMICS FOR PHYSIOTHERAPY STUDENTS - LECTURE MATERIAL

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The aim of this thesis is to offer the latest information of voice ergonomics based on the literature for physiotherapy students. The objectives of this thesis are to collect updated data of voice ergonomics and its methods to provide lecture material for physiotherapy students. Since physiotherapists use their voice daily in their work, there is a need of voice ergonomics. If voice ergonomics is studied during student-ship, there is a better chance to avoid voice problems.

Voice ergonomics is one aspect of ergonomics. It offers tools to enhance voice production, hearing and communication in general level. The aims of voice ergonomics are for example prevention of voice disorders in individual and in environmental levels. Voice ergonomics has mainly studied the voice problems among teachers.

As a result of this thesis lecture material for the Degree Programme in Physiotherapy was created. The lecture material consists of PowerPoint which provides evidence based information and a practical teaching video which contains voice exercises. The lecture material is concluded from updated literature concerning this topic as well as the videos topic. The content of the video was done in co-operation with Maria Svan and Liisi Pettersson the founders of Aanikurssit.fi.

CONTENTS

# 1 INTRODUCTION

Voice ergonomics has a long history in Finnish research, it has been studied for over 30 years. First studies handled the effects of noise and temperature on voice. Also, the impact of room acoustics on voice was discussed already back then. (Rantala, Sala 2016, 5.) Even though, problems with noise were already discussed in the 1950's by Mr. Philip J. Jory (1956, 217). He for example stated that noise damages ear and restricts communication.

Well-functioning voice is part of occupational health in many professions. Kindergarten teachers, speech- and language therapists and actors use their voice daily in their work. All in all, 30% of Finnish employees use their voice in their work daily. (Sala, Sihvo & Laine 2011, 5, 11.) Voice ergonomics is a way of practising and implementing voice to improve voice production, hearing and differentiation of voice. It aims towards easier communication (Sala 2004). It is multidisciplinary research which for example enhances environment to be suitable for voice usage and for voice ergonomics (Sala, Sihvo & Laine, 2011, 11).

Speaking is humans' primary communication method and physiotherapists use voice as a tool in their work (Fedurek & Slocombe 2011, 153; Talvitie, Karppi & Mansikkamäki 2006, 178-179). Physiotherapy education was originally started to increase patient's physical capability and rehabilitate injured soldiers. Nowadays physiotherapy aims to make assessments of client's functional capability in the areas of physical, mental and social health. (Talvitie, Karppi & Mansikkamäki 2006, 16).

Understanding and performing voice ergonomics while studying can diminish the risk of having voice impairments in the future (Sala, Sihvo & Laine 2011, 29). In professions such as nurse and physical instructor voice is used daily (Sala, Sihvo & Laine 2011, 11; Sala 2004). Since physiotherapist's use their voice as a tool they can be seen to belong to be part of the same voice user group. This means that physiotherapists belong to the risk group of having voice disorders. This lecture material was designed to diminish that risk among physiotherapists because it is provided for physiotherapy students.

# 2 AIM AND OBJECTIVE OF THE THESIS

The aim of this thesis is to offer the latest information of voice ergonomics for physiotherapy students. It will contain tools for them to use voice ergonomics as one perspective of ergonomics for themselves. Objectives of this thesis are to collect updated data of voice ergonomics and its methods to provide lecture material for future physiotherapists.

# 3 VOICE PRODUCTION

Voice is created in larynx. In mouth, it is turned into words. Words flow in the air as vibrations, creating pressure changes in the air. Finally, ear(s) receives this voice message. (Sala, Sihvo & Laine 2011, 6.) The message is called auditory sensation. It is received in the ear's eardrum where it turns into electrical impulses. Eventually brain interprets these electrical impulses into messages. (Sihvo, 2006, 12.)

First step of voice production is respiration. During exhalation, the diaphragm arises and when air is inhaled the diaphragm (Figure 1) lowers. This is followed by enlargement of lung volume when air fills up the lungs. (del Mundo 2001, 4-5.) The difference between normal breathing and breathing during speaking is the rhythm. Inhalation during speaking is relevantly fast, and exhalation takes longer because speaking mostly happens during exhalation. Even though, some speaking can also be produced by inhaling. (Aulanko 2009, 137-138.) Breathing control and voice production function together but breathing does not control voice production (Petterson 2017, 16).

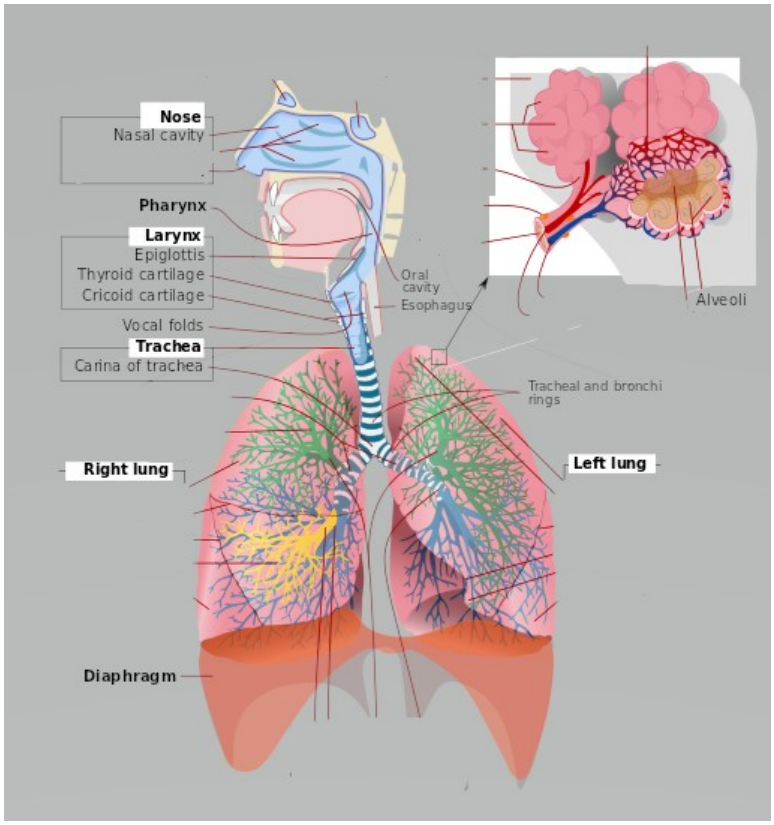


Figure 1 Anatomy of voice production (Website of Wikimedia commons 2017 modified by author)

The meaning of pressure changes in breathing can be seen in closer inspection of inhalation and exhalation. Inhalation is the function where air goes in to the lungs. For this action, there is a need of alveoli to change the pressure in themselves to be lower than the atmospheric pressure. If the pressure stays under atmospheric pressure air keeps on entering the lungs since air flows from high pressure to low pressure. Lungs expand during inhalation which increases the lung volume. For this to happen diaphragm and external intercostals must contract. While diaphragm contracts at the same time it also lowers down. The diaphragm is responsible for ¾ of all the air that gets in to the lungs during inhalation. The last ¼ of the air gets in by the contraction of external intercostals. (Tortora & Derrickson 2011, 936-938.)

In the exhalation the pressure in lungs must be bigger than in the atmosphere so that again air moves from high pressure to low pressure. While inhaling is active muscle work exhaling is passive. For exhalation to happen, first inhalation muscles must relax. The relaxation of inhalation muscles presses ribs down and at the same time also

diaphragm releases its contraction. This decreases thoracic cavity size which eventually decreases lung volume. Even though muscles play their part in this it is important to remember that elastic recoil from lungs and chest wall release their stretch which fires back causing the exhalation. (Tortora & Derrickson 2011, 939.)

Larynx or voice box (Figure 2) protects airways and enables voice production (Kleemola, L. & Sala E. 2013, 1). It is placed vertically from fourth cervical vertebrae to sixth (C4-C6) in the middle of the neck. The oesophagus is posterior to larynx and it stays between the borders of pharynx and trachea. (Tortora & Derrickson 2011, 923.) Larynx is covered with cartilage which holds and defines the position of vocal folds. In voice production, the most important cartilage structures are arytenoid cartilages because they are attached to vocal folds. Other cartilages in larynx are thyroid cartilage and tracheas cartilage Cricoid cartilage. The epiglottis also belongs to speaking structures even though its main function is to protect trachea during swallowing. (Aulanko 2009, 138, 140.)

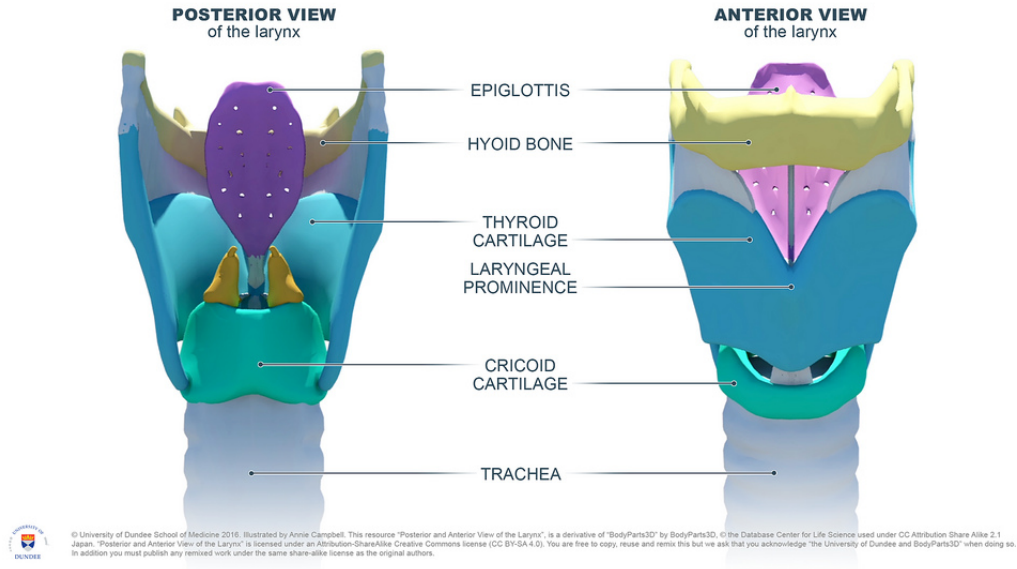


Figure 2 Anatomy of Larynx (Website of Flickr 2017)

Vocal folds (Figure 3) or true vocal cords are one pair of larynx's mucous membrane. The other pair of larynx folds are called ventricular folds or false vocal cords which are placed superior to vocal folds. They do not have a role in voice production. Area between ventricular folds and vocal folds is called Rima vestibuli. (Tortora & Derrickson 2011, 923.)

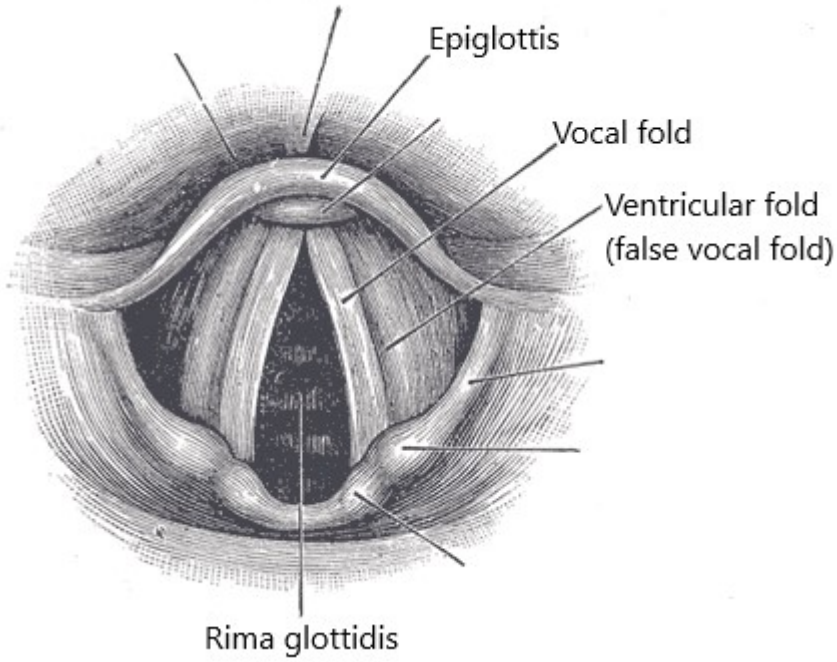


Figure 3. Anatomy of vocal folds (Website of Wikimedia 2017 modified by author)

The muscles used in voice production are intrinsic muscles of larynx. These muscles attach to vocal folds and rigid cartilage. In vocal folds, mucous membrane elastic ligaments are elongated between the rigid cartilages of larynx. Cartilage is shifted by intrinsic muscles of larynx which causes elastic ligaments to tighten. This elongates vocal folds and that's how Rima glottides narrows down. (Tortora, Derrickson 2011, 925.)

The muscles which open and close vocal folds define also the shape and density of them (Kleemola & Sala 2013, 189). The abduction of vocal folds is produced by posterior cricoarytenoid muscle (Figure 4). The adduction is produced by lateral cricoarytenoid muscles which closes rima glottides. Other muscles either stretch or shorten the vocal folds. (Tortora & Derrickson 2011, 92.)

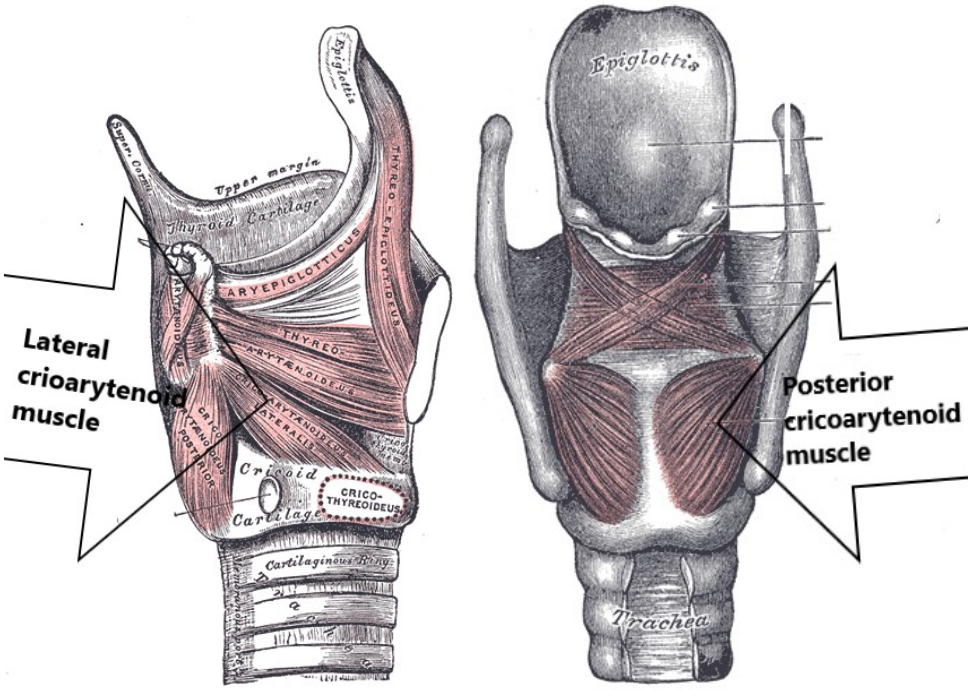


Figure 4 Lateral and posterior cricoarytenoid muscles (Website of Wikimedia commons 2017 modified by author)

Tracheal pressure provided by the power of lung function enables vocal folds to vibrate and pulls vocal folds apart. Cycle of vocal folds opening and closing moderated subglottal pressure and trans glottal flow provides short pulses of sound energy. Vocal tract resonance is oscillation which is created in vocal structures. When vocal folds create sound waves they travel through the supraglottic air column into the pharynx, oral and nasal cavities. It also travels through articular structures like tongue and teeth. The air molecule creates resonance in these spaces. Resonance is present when sound is strengthened or extended as acoustic sounds echo off another structure. (Stemple, Roy & Kabel 2014, 13, 18.) Resonance is needed to create speech from other sounds. Resonance also makes our speaking voice unique. (Tortora & Derrick 2011, 926.)

Intrinsic muscles of larynx and sound pressure regulate the tone and pitch of the voice (Kleemola & Sala 2013, 189). When muscles of vocal folds are tightened more vibration is created and this makes pitch higher. When muscles are loosened lower pitch, voices are produced (Tortora & Derrickson 2011, 926-927). Women's vocal folds vibrate 200-300 times per second and with men's half of that (Sala 2004). The

very last phase of speaking is produced by muscles of face, tongue and lips. They help with pronunciation and finish the sound which starts from the respiration. (Tortora & Derrickson 2011, 926-927.)

# 4 VOICE ERGONOMICS

Voice is produced through the lungs and vocal folds. Vocal folds vibrate due the airflow passing through vocal tract. This airflow is generated by lungs. (Website of National Institutes of Health 2017.) Speech is advanced voice which enables advanced communication. Even though the pitch, volume and tone of voice, are more related to prenatal communication. The complexity of speaking distinguishes humans from other animals. (Pitkäranta 2009, 2027-2028.)

There are several descriptions and definitions for ergonomics. According to international ergonomics association (2017) the definition of ergonomics is following:" Ergonomics or human factors is scientific discipline concerned with understanding interactions among humans and other elements as a system and profession which applies theory, principles, data and methods designed to optimize human well-being and overall system performance." (Launis & Lehtelä 2006, 12.)

Voice ergonomics is perception of work-related voice problems and knowledge how to enhance voice production and speech (Södersten & Lindhe 2007). Voice ergonomics aims to efficient and healthy vocals. On the other hand, it also aims to create possibilities to hear and differentiate voice easier to ease communication. Voice ergonomics can be for example acts which decrease noise. (Sala, Sihvo & Laine 2011, 10.)

Voice ergonomics is acts which prevent voice disorders. This can mean for example methods which relieve voice disorders' symptoms. In individual level voice ergonomics is taking care of health and voice. It may include for example healthier lifestyle choices and exercises which relax voice. On the other hand, voice ergonomics

is also about environmental work such as building work places voice ergonomically. (Rantala & Sala 2016, 5.)

# 5 VOICE ERGONOMICS FOR PHYSIOTHERAPISTS

Speaking and listening are enormous parts of many professions and jobs. 30 % of Finnish employees use their voice in amply during their work day (Sala, et al. 2009, 5). For example, professions like teachers, singers, doctors, physical instructors and architects implement voice ergonomics daily in their work (Sala, Sihvo & Laine 2011, 10-11). Physiotherapists are professionals with assessing physical performance and ergonomics. They use speaking as a tool to assess and instruct their clients. (Talvitie, Karppi & Mansikkamäki 2006, 178-179.)

Musculoskeletal problems are the most common occupational health problems among physiotherapists. Typical problems are back pain and strains from repetitive hand movements. Especially back and neck pain are associated with awkward body postures during physiotherapy. Physiotherapists who perform breathing exercises are also in a risk of having infection usually related to respiratory tract. (Bratting, Schablon, Nienahaus & Peters 2014, 9-11.) Awkward postures during speaking especially in the neck area increase vocal loading (Gilman and Johns 2017, 131). As well, for example respiratory infections can cause voice disorders (Sebastian, Suresh, Simon & Ballraj 2012, 6).

Physiotherapist may work in pools, outdoors and in gyms (Artz et al. 2015, 18; Foley, Halbert, Hewitt, & Crotty 2003, 1162; MacCluskey et al. 2015, 3). One instructing style is verbal guidance which is needed especially in the beginning of learning new motor skills (Talvitie, Karppi & Mansikkamäki 2006, 184). Voice ergonomics should be considered if the work includes speaking (Sala, Sihvo & Laine 2011, 14). For example, the absence of reflective surfaces outdoors increases vocal effort. Big spaces and background noise also make hearing and speaking difficult. (Sala, Sihvo & Laine 2011, 24.)

It is important to realize the risk factors in speaking. One way to avoid voice problems is to know when and how to use voice. (Sala, Sihvo, Laine 2011, 29.) Physiotherapists do not have to use verbal guidance in every instructing situation. Manual guidance is needed for example in facilitation which is used to correct movement or help the performance. On the other hand, demonstration of movement and feedback from the mirror are commonly used visual instruction methods by physiotherapists. (Talvitie, Karppi & Mansikkamäki 2006, 183, 187, 191.)

Physiotherapists work also as professional with voice disorders. Especially with muscle tension dysphonia physiotherapy has been effective method to relieve voice symptoms. (Tomlinson & Archer 2014, 117-128.) Other voice professionals are for example phoniatricians and speech and language therapists' (Lehti 2014: Sihvo 2004). Phoniatrician is a doctor specialized in voice disorders, whose work includes examination of the client and his or her problem (Lehti 2014). Speech and language therapists' job is to instruct voice ergonomics for their clients and produce rehabilitation for voice disorder patients (Sihvo 2004).

# 6 VOICE DISORDERS

When speaking voice cannot be used normally it is commonly caused by a voice disorder. A voice affected by a voice disorder might break down and it usually cannot be used for a long time. This type of voice may fade away and the sounds of it are abnormal. The voice sounds can be rough, high or low. There are also several other signs and symptoms like hoarseness which can be related to voice problems. Luckily, voice professionals can define voice disorders from the voice symptoms. Voice disorders are categorized into functional and organic disorders. (Sala, Sihvo & Laine 2011, 14.)

## 6.1 Medical conditions related to voice disorder

With adults the most common voice disorder is Functional Voice Disorder (FVD). FVD means abnormal voice without any physical problems like lesions or other ana-

tomical abnormalities. On the other hand, vocal nodules or thickening of vocal cords can be related to FVD. (Chan, McCabe & Madill 2013, 334.) In this situation tissue changes are so minor that they are irrelevant compared to changes in organic voice disorder since in organic voice disorder there is a clear anatomical lesion. (Kleemola & Sala 2013, 193; Sala, Sihvo & Laine 2011, 15.) The lesion often disturbs glottal closure or vocal folds vibration (Sala, Sihvo & Laine 2011, 15).

Organic secondary manifestation of functional voice disorder is more commonly known as singer's nodules. The nodules are caused by untreated hyperfunctioning voice impairment. Hyperplasia is formed in the medial border of vocal folds and edema arises since tissue swells inwards. In the end swellings undergo fibrosis and turn into hard nodules. Due to the nodules, vocal folds are unable to close in the affected area. (Reiter, Hoffman, Pickhard & Brosch 2015, 330.) The nodules arise bilaterally in vocal folds when voice strain happens repetitively. Singer's nodules are typical outcome of speaking loud and intensively without resting. (Sala, Sihvo & Laine 2011, 15.)

Muscle Tension Dysphonia (MTD) is one type of FVD. In MTD extrinsic laryngeal muscles have malfunction which leads to tension in the larynx's muscles. This diagnose is more common with females and it is diagnosed approximately 10-40% of all the voice disorder patients even though the most common FVD is fatigued voice. (Kleemola & Sala, 2013, 196.) Vocal fatigue is defined to be increased vocal effort which growths related to time. It has also other recognizable features like reduced pitch range, vocal power and control of the quality of voice. Vocal fatigue heals by resting. (Solomon 2008, 254, 263.)

Acute laryngitis is the inflammation of larynx and mucous membrane of vocal folds which lasts less than three weeks. Symptoms of laryngitis can be hoarseness, sore throat and mucus in nasal cavity (rhinorrhea). (Reveiz & Cardona 2015, 5.) Most common reason for organic voice disorder is acute laryngitis. It covers 40% of the hoarseness voice diagnoses. During acute laryngitis, excessive and unnecessary voice usage should be avoided. On the other hand, total voice resting should be avoided as well to diminish the risk of losing the voice completely (aphonia). (Reiter, Hoffman, Pickhard & Brosch 2015, 330-331.)

Vocal fold polyps are lesions in vocal folds which may interfere glottal vibratory patterns and eventually change the structure of vocal folds. Vocal fold polyps can for example inhibit glottic closure, decrease vocal flexibility and the vibratory movement of contralateral fold. (Dursun et al. 2010, E12.) Polyps can be caused by inflammation as well as mechanical strain (Sala, Sihvo & Laine 2011, 16).

Vocal fold paralysis is associated with malfunction or absent function of vagus nerve or its distal part recurrent laryngeal nerve. It is neurological condition where there is absent or reduced movement in one or both vocal folds. It is usually related to laryngeal cancers or injuries during surgeries. (Li, Garret & Zealer 2017, 203.)

## 6.2 Causes of voice disorder

Factors which might lead to voice disorders can be divided in three groups: chronic vocal loading, environmental loading and psych emotional risk factors. (Niebudek-Bogusz & Swilinska-Kowalska 2013, 659.) Since many major causes of voice disorders are medical conditions they can also be thought to be risk factors. Respiratory function is part of speaking so asthma and medication related to it can irritate larynx. Also, basic medical conditions including allergic rhinitis, laryngitis, and gastroesophageal reflux are related to voice problems since they can cause undesirable changes in vocal fold mucosa. (Sebastian, Suresh & Ballraj 2012, 6.)

Unidentified hearing loss causes increased vocal effort since the speaker must increase the volume of speech to gain feedback of their own voice (Sebastian, Suresh, Simon & Ballraj 2012, 6). On the other hand, loud speaking is commonly used with hearing loss patients which also strains vocal system (Sala, Sihvo & Laine 2011, 23). All in all, personal lifestyle choices have effect on voice. Lack of sleep hampers the control of voice when smoking and alcohol usage increase the risk of laryngeal infection. (Sala, Sihvo & Laine 2011, 21.)

Different type of personality types can predict voice disorder. The Roy and Bless theory of the dispositional bases of vocal nodules and functional dysphonia suggest

that neuroticism as a personal aspect starts Nonspecific Arousal System. Extraverted people use Behavioural Activation System which starts from the thought of reward and non-punishment which eventually leads to active approach. With introversion fear of punishment, frustration and threat starts Behavioural Inhibition system which leads to passivity and functional dysphonia. (Roy, Bless & Heisey 2000, 744-745.) In practical way, a person who speaks a lot is obviously more prone to have changes in the vocal tract. On the other hand, a shy person might be afraid of using voice which can develop functional voice disorder. (Sala, Sihvo, Laine 2011, 20.)

Functional voice disorder is more common with females than males with 2/3 diagnosed cases being women. There is clear evidence that negative feelings related to problematic, difficult and severe life situations might be a risk factor for developing functional voice disorder. Cases of sexual abuse, violence or strangulation during their lifetime are more common with functional voice disorder women than women in control group or organic voice disorder group. Women with functional disorder also suffer more commonly of anxiety, since they express all their feelings more compared to the other participants. (Baker, et al. 2013, 547, 548,559.)

Professional speakers use their voice in amply everyday which might cause them to use inappropriate techniques which can eventually cause incorrect compensation of voice production (Niebudek-Bogusz & Swilinska-Kowalska 2013, 659). Mucous membrane of vocal folds is strained from monotonic speaking along with as too high or low pitch. On the other hand, raised volume of voice increases the pressure in vocal folds. In loud speaking, vocal folds hit each other when the collision causes changes in vocal folds. (Sala, Sihvo & Laine 2011, 21.) All in all, laborious speaking fatigues laryngeal muscles which can cause mechanical strain to vocal folds. Also, personal anatomy and other factors might increase the risk of vocal loading. (Solomon 2008, 245.)

Environment also has its effect: pollution, poor humidity and temperature changes may affect to larynx's mucous membrane and increase vocal effort (Niebudek-Bogusz & Swilinska-Kowalska 2013, 659). Poor acoustics also lead to excessive voice usage, and longitudinal voice usage with background noise has been found to be a serious risk factor causing voice disorder (Bottalico, Graetzer & Hunter 2016,

2878; Niebudek-Bogusz & Swilinska-Kowalska 2013, 659). Figure 7 shows how background noise increases vocal volume. The figure uses SIL- values which are covered in Table 1. SIL-values defines the volume difference between speech and background noise next to hearer's ear. (Launis & Lehtelä 2011, 281.)

Table 1. Speech's understandability (Launis & Lehtelä 2011, 281)

| **Speech understandability** | **SIL (dB)** |
|---|---|
| excellent | >21 |
| good | 15-21 |
| moderate | 10-15 |
| poor | 3-10 |
| incomprehensible | <3 |

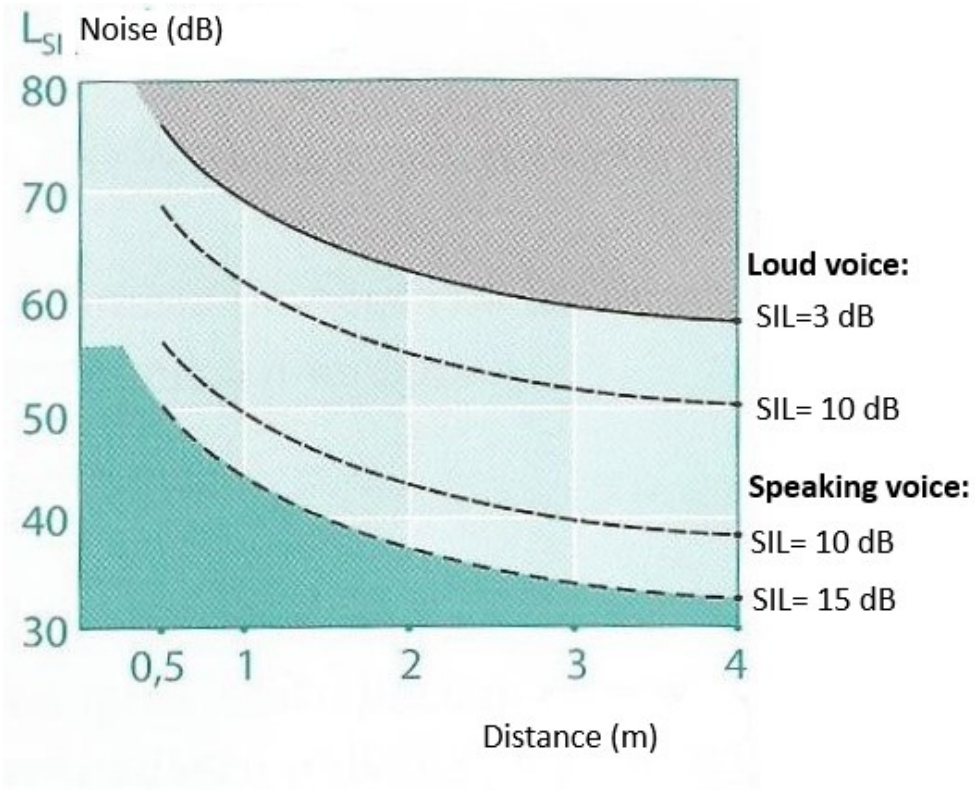


Figure 7. The effect of a background noise on voice (Launis & Lehtelä 2011, 281)

# 7 PREVENTION OF VOICE DISORDERS

Healthy voice is easy and effortless to produce (Sihvo 2006, 20). Prevention of voice disorder aims to healthy vocals. It includes knowledge of voice, inspection of voice usage and skills how to use the voice. Healthy voice production should be learned during the studying if speaking is included the future job description. (Sala, Sihvo, Laine 2011, 29.)

Incorrect head and neck posture influence negatively on voice production. Even the posture before speaking has an effect vocal effort. When muscles are stabilized, the antagonist and agonist muscles repeal the affects one and another. In movement, the changes are imbalanced which can lead to increased vocal effort. (Gilman and Johns 2017, 131.) Speaking effort increases in incorrect posture because breathing is heavier than in optimal posture. It is also important to talk towards listeners since cervical spine protraction or rotation increases tension in larynx. In optimal standing position, inner organs are pushed down which creates more space for voice production structures. (Sala, et. al. 2009, 34.)

Acoustics of room affects the labor of speaking. Bottalico, Graetzer and Hunter (2016, 2878) tested how vocal effort is affecting speaking style. Findings were that room acoustics and short-term vocal fatigue are related to each other. The study included changing the pitch of voice and changes in acoustics. It was noted that reflective surfaces were reducing voice effort especially when speaking was loud.

When voice is raised incorrectly vocal folds and their muscles tighten. This can be avoided by learning the right technique to produce loud voice. A good posture is the starting point of healthy loud speaking. Once posture is found, the next step is breathing. Inhalation should be done through the nose. An open larynx gives the air opportunity to run free and that is why jaw should be relaxed. With these instructions voice is produced by flowing air instead of tensed vocal folds. (Sala, Sihvo & Laine 2011, 30.)

Dehydration may increase vocal effort and it can cause tissue damage if there is fluid compression accumulation in vocal folds. Reduced vocal folds thickness is also re-

lated to dehydration. These facts show the importance of hydration. Hydration treatments like increasing water intake, humidifying surroundings and nebulizing solutions in the airway seem to have positive effects on vocalization. Evidence supports for hydration affecting positively vocal health and it might even promote laryngeal health. (Sivasankar & Leydon 2010, 171-175.)

Painful voice production or laryngeal pain should be taken seriously but if vocalization is natural it should be relevantly safe. Focused acute pain, along with unpleasant voice changes, or painful phonation should be taken seriously. In these mentioned cases, it is important to seek professional help to solve the problem. (LaPien & Peter 2008, 24-29.)

# 8 TREATMENT FOR VOICE DISORDER

Voice therapy is one of the treatment options for functional voice disorder. Together indirect and direct voice therapy is the most effective treatment style in treatment of functional voice disorders. Direct voice therapy means actions which change in vocal function to enhance vocal efficacy and voice quality. Indirect voice therapy is management which does not change vocal system structures. It includes for example patient education, counselling and voice rest. (Chan, McCabe & Madill 2013, 335.)

There is huge amount of direct voice therapy for dysphonia. Voice specialists use techniques like pitch extension and elimination of glottal track as direct voice therapy for dysphonia. It also includes exercises such as humming and nasal consonants which are familiar with non-voice specialists. It is important to remember that, there is a recommendation that voice therapy should be created according patient's individual needs. (Chan, McCabe, Madill 2013, 335, 339.)

Voice rest is a tool in voice therapy, but it can also be thought to be preventive action. In conservative voice rest, normal voice usage is allowed but whispering or loud speaking should be avoided. It is also recommended to have sixty minutes of voice

rest after great voice usage session. Voice rest also includes the idea of not speaking with anyone too far away to touch. (LaPine & Peter 2008, 24-29.)

Few physiotherapeutic manual therapy methods have been found to be effective in management of voice disorders. These include methods such as laryngeal massage and massage in neck or/and in shoulder girdle area. Also, passive stretches in the upper body seems to have positive effects on vocal function. The idea of these manual techniques is obviously to release muscle tension which is disturbing voice production. For example, massage reduced VAS- scale points and enhanced vocal quality. (Cardoso, Meneses & Lumini-Oliceira 2017, 6-8.)

Medical treatments are part of treatment of voice disorders. Especially in treatment of reflux and thyroid problems are taken care of by right type of medication. (Pedersen & McGLashan, 2012, 3.) Steroid injections have been found to be effective in the treatment of vocal fold polyps and nodules. For example, in Buckmire's research (2017) injections effect lasted over two years in half of the patients. Voice therapy and surgery are potential treatment methods with vocal nodules. Even though voice therapy is usually the primary treatment style surgery is sometimes the better option. (Pedersen, M. & McGlashan, J. 2012, 6.)

# 9 EFFECTIVE VOICE EXCERCISES

The idea of semi-occluded vocal tract exercises is the reduction in vocal tract while voice production. These exercises can be performed by articulators' lips and tongue, nostrils or with a tube. Semi-occlusion creates greater supraglottic pressure instead of trans glottal pressure. This type of voice production diminishes vocal folds' adductors and abductors muscle work and voice gains acoustic capability. It diminishes the risk of vocal injuries because even in high pitch it causes relevantly small oscillation. (Meerschman, et al. 2017, 2520.)

In Meerscman et al (2017, 2519, 2525, 2531) research resonant voice training and straw phonation had few positive outcomes with students who did not have voice

problems. Training included two 30 minutes sessions a week for a 6 weeks period. Resonant voice exercises included humming, connecting nasal consonants with rounded vowels, unrounded vowels and consonants exercises. Pitch and loudness exercises were also involved. Pitch gliding, loudness shifts, and melodies are examples of pitch and loudness exercises. Also sentences, words and phrases were trained. The risk of voice disorder was diminished after the training period.

In the study mentioned above, straw phonation training was done with usage of a drinking straw which was eventually changed into a smaller straw. Exercises developed from breathing through nose to vowels to pitch and loudness exercises. Eventually exercises developed to speaking sentences through straw. After the exercising period, the risk of having a voice disorder was decreased. Also, vocal capacity increased because intensity and enlargement developed. (Meerschman et al. 2017, 2525, 2531.)

As methods, voice production through flow-resistant tube and Vocal Function exercises, are equal in improving voice qualities in mild to moderate dysphonia and vocal fatigue. In Kapsner-Smith et al (2015, 540-543, 546) study, Vocal function exercises were focusing on semi-occlusion at lips techniques with pitch glides. Flow-resistant exercises were varying pitch and loudness, concentrating abdominal-thoracic breathing and phonation of words through the straw. Comparison was done by using self-report of voice quality of life.

Nasal sounds (m, n, ŋ) are commonly used as voice exercises. In nasal sound voice exercises nasal gate opens which creates actions in body. This lowers the larynx down and decreases vocal folds adduction. The aim is to ease the voice production and prevent voice problems (vocal hyperfunction). These type of voice exercises aim to find optimal vocal tract and glottis impedance. (Laukkanen & Leino 1999, 215-216.)

# 10 LECTURE MATERIAL

The content of the material is based on the level of the spectators. The audience is in the levels of “Novice” and “Advanced beginner”. When a person is in the level of a novice, there is a need for guidance and no experience on the topic yet. On the other hand, “Advanced beginner” already had some knowledge and is starting to develop base for the competence of the topic. Also, connecting information for earlier information may improve learning and for example using multiple memory pathways (visual, auditory and kinesthetic) augments learning. (Plack & Driscoll 2011, 70, 88.)

Because the audience will be third year physiotherapy students, they already have knowledge of cardio-, and respiratory functions which makes them “Advanced beginners” but they do not have any information of voice ergonomics which makes them “Novice”. These factors were determining the content of the material. Material is also connected to earlier studies because it includes information of breathing. The material uses visual, auditory and kinesthetic learning methods. It contains PowerPoint presentation with text and pictures and video including all the memory pathways.

The lecture material was created out of the updated data which was collected to this thesis. The topics for the lecture material were chosen to fulfill the aim of offering physiotherapy students the latest information on voice ergonomics. It consists of knowledge which is needed to understand and apply voice ergonomics. The lecture is planned to keep in the same order as the PowerPoint suggests. First information is given in the form of the PowerPoint and after that there is video of practical exercises which prevent voice problems.

The PowerPoint-presentation starts with an introduction of voice ergonomics, because it probably is not well-known subject among physiotherapy students. Since the basics of voice production are in breathing, it was discussed quite widely in this material. To understand voice ergonomics the structures and functions of voice production must be understood and that is why the functions and anatomical pictures are placed in this PowerPoint. The author also placed some questions for the PowerPoint

to activate the audience during the future lectures. The slides of the PowerPoint can be found from the appendix of this thesis.

The video is the practical part of this thesis and it contains few voice exercises and instructions on how to raise voice correctly. The PowerPoint presentation opens few key concepts before the video, so the content of the video is easier to understand. Exercises are based on theories that were introduces in this thesis of. Aanikurssit.fi was also helpful source among the other sources for the exercises. The video for this thesis is downloaded to the Youtube as a private file. The whole material (The PowerPoint and the video) is also given to the supervisor of this thesis with a memory stick.

The most important part of this lecture material is physiotherapist voice ergonomics and preventive measures which everyone can use to prevent voice disorders and to apply voice ergonomics easily every day. On the other hand, the knowledge of voice disorders can help physiotherapy students to recognize the symptoms and help them to find suitable treatment for it.

# 11 THESIS PROCESS

A project has a beginning and end which are covered for a specific goal orientated purpose. Since a project has a goal which is reached within specific timeline, a project is also temporary. The limited resources and timeline are included in the definition of a project. Functions like scheduling, designing and advertising et cetera can also define certain projects. One representative example of a project is that it is created for a client. This automatically creates one goal for the project which is of course to satisfy customer's wishes and needs. (Pinto 2016, 25-26.)

This thesis was done as a project since it covers multiple characterizes of a project. This project included a planned and specific timeline which also limited this project, even though some changes happened during it. Planning, researching and creating are examples of functions which were part of this thesis. One clear characterize of a project in this thesis was that it was created for a client, which also defined the objec-

tive of this thesis. The objective was to create lecture material for the Physiotherapy degree programme at Satakunnan ammattikorkeakoulu.

The thesis project started in January 2017 when the topic was chosen. The topic was proposed by the supervisor and the thesis was going to be a lecture on voice ergonomics for the Physiotherapy degree programme in Satakunnan ammattikorkeakoulu. The planning of this thesis happened in schedule and the presentation of project plan was presented 16th of February. Also, the agreement was signed in February 2017. The theory for this thesis was written in September-November 2017. It was concluded from the planned subjects and the written content of this thesis remained mainly the same as it was planned.

This projects timeline (Table 2) was approved by the supervisor and it was presented on 16th of February 2017. The timeline was planned according authors clinical practices which were organized in February-May 2017 and in October 2017. The specific date 20.10.2017 of lecture was agreed with the supervisor in September 2017. The specific thesis presentation day was agreed to be 17th of November.

Table 2. Proposed timeline of this project

| **Task** | **Date** |
|---|---|
| Starting bachelor thesis project plan | February 2017 |
| Research and writing the theory | September 2017 |
| Finishing theory and having the lecture | November-December 2017 |
| Thesis presentation | November-December 2017 |

The true timeline of this project is presented in Table 3. Changes to the timetable occurred especially in October 2017 when the aim and objective of this thesis changed. Research and theory writing was prolonged, so it was decided that this thesis would provide only the lecture material for the Physiotherapy degree programme instead of lecture and material. Aanikurssit.fi was contacted also in October 2017. Aanikurssit.fi offered some of their material for this thesis and for example their personal tips are used in the video. PowerPoint of voice ergonomics for the lecture material was created in of November-December 2017 and video was shot and edited in January

2018. The final thesis presentation day and completion of this project was changed to be in January 2018.

Table 3. True timeline of this project

| **Task** | **Date** |
|---|---|
| Starting Bachelor Thesis project plan 5cr | 16.2.2017 |
| Research and writing the theory | September-November 2017 |
| Contacting Aanikurssit.fi | October 2017 |
| Finishing theory and creating the lecture material | November-December 2017 |
| Finishing written parts and shooting and editing the video | January 2018 |
| Thesis presentation | 19th of January 2018 |

# 12 DISCUSSION

This thesis was changed from a lecture to lecture material since the timeline was prolonged. Because this lecture material is provided to school, mainly to the use of the supervisor of this thesis, some instructions were given what this material should contain. The plan of thesis was approved 14.2.2017 when supervisor also noted that the plan was, and what she expected from this thesis. Later, the supervisor and her colleague suggested that this thesis could also contain video of voice ergonomics exercises. The video came even more important for this thesis when it was decided that author wouldn't have the lecture for physiotherapy student.

The plan from having a lecture changed so there was no longer the opportunity to have feedback from the lecture material. The feedback might have changed the lecture material to different direction and it could have given new ideas for the author. Luckily the supervisor of this thesis has in the end the possibility to decide which parts she is using of this thesis and the lecture material during the teaching.

Finding general information of voice ergonomics and for example voice disorders was relevantly easy. It was nice to notice that there is especially Finnish research of voice ergonomics. Since the target group is third year physiotherapy students their level was also familiar to the author. It was important to ensure that the students have enough information of the functions and basics of voice even if it would be repetition from the earlier studies. The PowerPoint was created out of written thesis and concluding it went relevantly easily. First edition of the video was shot in November and fulfilled in the beginning of December. The author wasn't pleased with the video, and decided to shoot it again in the beginning of January.

Second shooting of the video was much better, and that version was also edited. Editing of the video happened with iMovie. Editing took more time than the author expected, but in the end, it was ready on 9th of January. The author also cut one exercise of the video because the video seemed to have too much information. The exercise which was cut out handled "controlled exhalation" which is related to Complete Voice Technique (CVT) –principle. Also, there wasn't enough free clinical support CVT and "controlled exhalation" effects on voice which made the topic to be left out from the video.

This thesis is based on physiotherapists' needs of voice ergonomics. Physiotherapists use their voice during their work day in different type of environments but there were no clinical studies concerning the matter. This fact made creating this thesis problematic. It is generally known that for example physical instructors and nurses belong to the voice user group but finding the correct information of physiotherapist voice usage was difficult. Since the information was lacking physiotherapist as a voice user was compared to physical instructors and nurses. Even though, physiotherapist's voice usage is probably somewhere between a physical instructor and a nurse.

Since, some scientific information is missing from this thesis' its credibility can be questioned. Physiotherapist's voice use should be clearly studied more but since this thesis was clearly limited by the time and resources it can't offer that type of information. Even though, the other information of this thesis is in general level of voice users which makes it beneficial for everyone. If the view of physiotherapist voice

usage is left out of this thesis all the information is updated data of voice ergonomics. But since this thesis is a material to physiotherapy students it must give some ideas for good voice usage in that specific profession.

Because this thesis didn't include any research question some of possible questions were aroused. It would be interesting to study how physiotherapists feel about voice ergonomics and do they think they would need it. On the other hand, research questions like what type of voice using situations they have, and do they have any problems with their voice would have been interesting to know. For the future, it would be beneficial to study physiotherapist own thoughts of their voice ergonomics and the need of it. This type of study could be done for example in a form of a survey. This also made the author question whether the above-mentioned study, should have done first and the material after the study.

Physiotherapist's role in voice ergonomics seems to have two different aspects. Physiotherapist can work as a professional in the area. They give clients treatments and tools how to relax tensed areas concerning voice production. On the other hand, they might be the client for language and speech therapist if there isn't knowledge of voice ergonomics. In both roles, it is crucial to understand voice, it functions and the possible problems. On that sense, this thesis and the lecture material offers new and important information. Even though, the need of information is wider than this thesis can provide, this thesis offers decent basic education on the matter.

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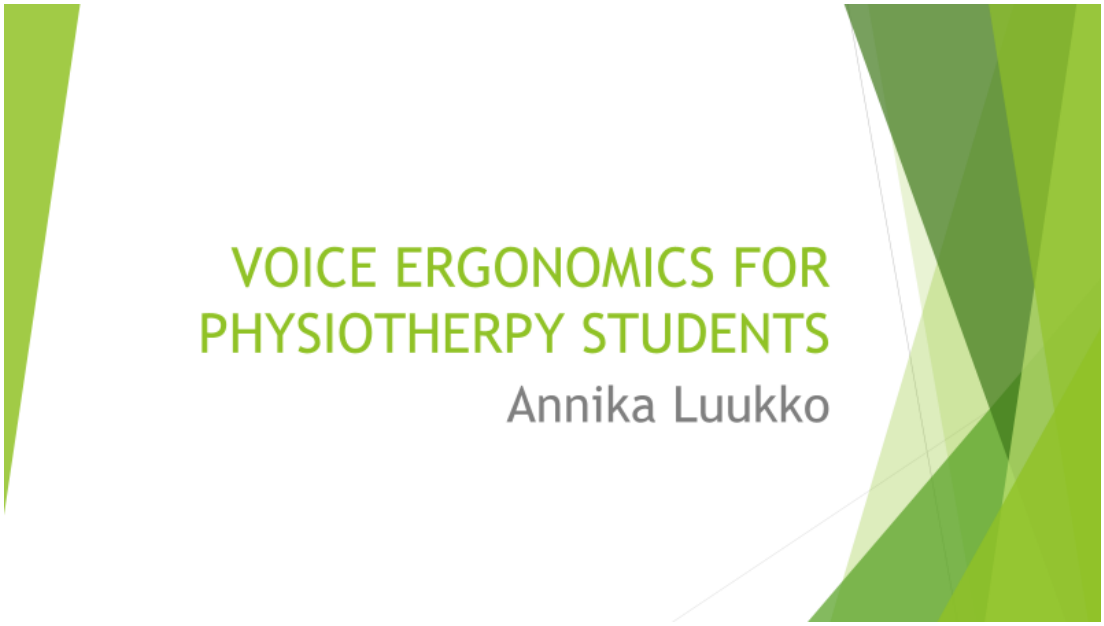
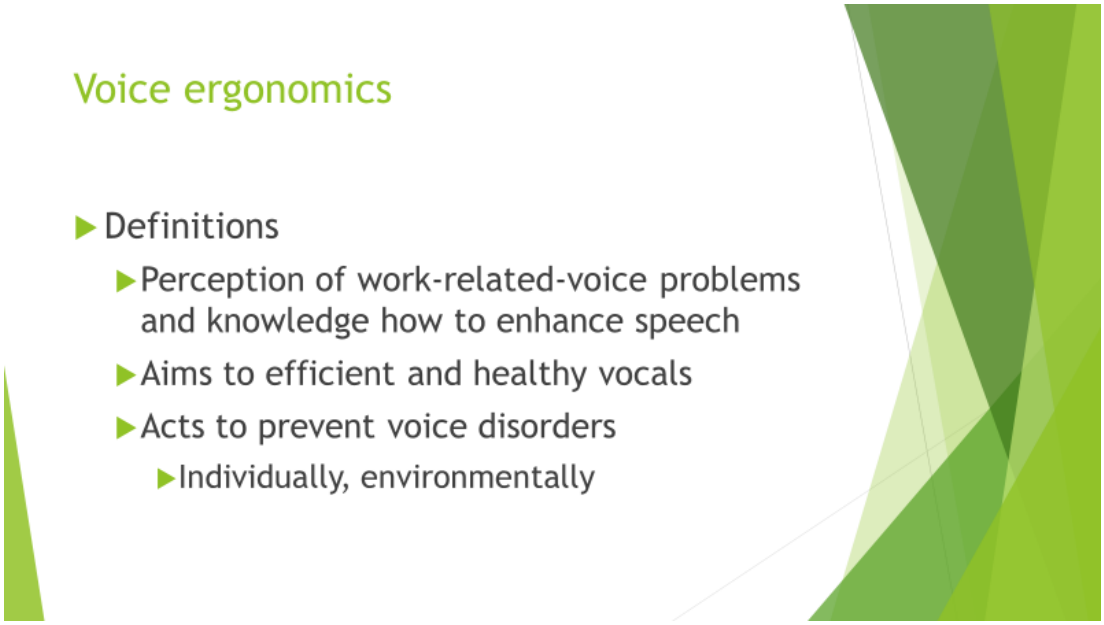
APPENDIX 1

SLIDES OF THE POWERPOINT



# Respiration in voice production

Active inhaling

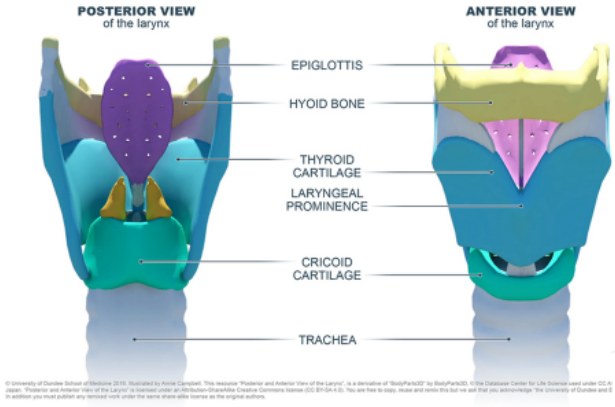
- The diaphragm does ¾ and intracostals ¼ of the inhaling
- contraction of the diaphragm and the external intracostals →alveoli pressure under atmospheric → air in

Passive exhaling

- Elastic recoil stretch release does the work
  - Alveoli works vice versa
  - Inhalation muscles relax → presses ribs down → the diaphragm releases contraction= decreases thoracic cavity → decreases lung volume

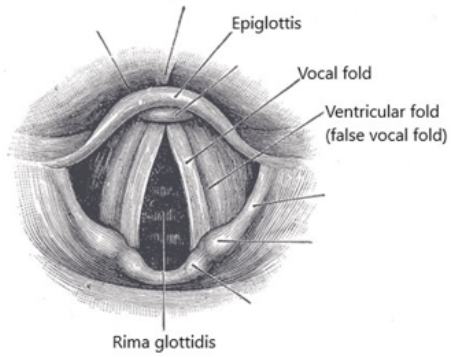
- Speaking happens during exhalation → short inhalation and longer exhalation

# Anatomy of voice production structures—Larynx



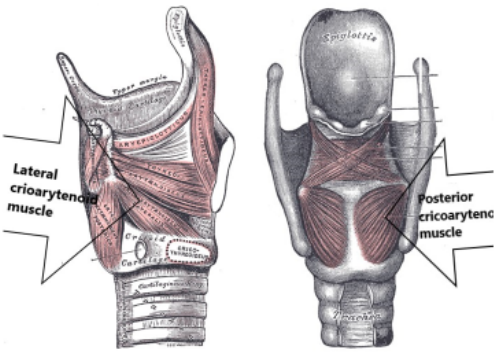

Anatomy of Larynx (Website of Flickr 2017)

# Anatomy of voice production structures- Vocal folds




Anatomy of Vocal folds (Wikimedia 2017 modified Annika Luukko)

## Muscles of the larynx




- Lateral cricoarytenoid=adduction
- Posterior cricoarytenoid=abduction
- Other muscles stretch or shorten vocal folds

(The Website of Wikimedia 2017 modified by Annika Luukko)

## Resonance

- Tracheal pressure →vibration → vocal fold abduction
- Sound waves through supraglottic air column → pharynx → oral and nasal cavities → tongue and teeth
- Air molecules create resonance
- Resonance makes speaking voice unique

## Tone of voice

- More vibration → higher pitch
- Women's vocal folds vibrate 200-300 per second
- Men's vocal folds vibrate 100-150 per second

## Tone of voice

- More vibration → higher pitch
- Women's vocal folds vibrate 200-300 per second
- Men's vocal folds vibrate 100-150 per second

## Jobs where voice ergonomics is present

- 30% of all Finnish employees uses their voice a lot during their work day
  - Nurses, physical instructors "voice users"
  - Teachers, singers "use's voice a lot"
- People who enable voice ergonomics
  - Architects, speech and language therapists

## Physiotherapist voice ergonomics

- Voice user group
- Physiotherapist occupational problems
  - Awkward postures, respiratory infections can increase the risk of voice disorder

## Instructing methods

- Which ones we use?

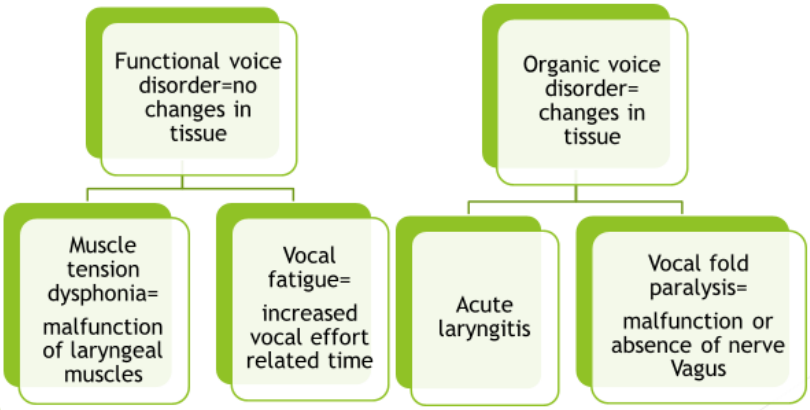
## Instructing styles

- Verbal → is it always needed?
  - outdoors vocal effort increases due the lack of reflective surfaces
- Manual
  - facilitation
- Visual
  - demonstration

## Symptoms of voice disorders

- Voice
  - can't be used normally
  - breaks down
  - fades away
  - can't be used for long time
  - sounds are abnormal: for example rough, high or low

## Voice disorders




## Vocal nodules, ”singers nodules"

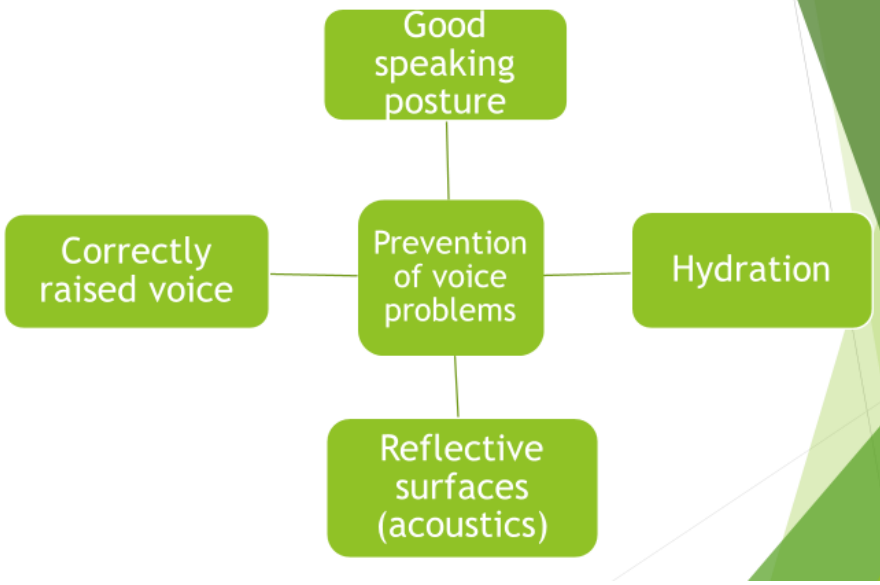
- http://www.ohniww.org/wp-content/uploads/2013/09/vocal-nodules.jpg

- Speaking loud and intensively
- Voice impairment
- Tissue swells inwards → edema
- The edema goes through fibrosis
- Hard nodules arise bilaterally

## Vocal polyp(s)

- https://classconnection.s3.amazonaws.com/33/flashcards/602033/jpg/vocal_polyps1337633658309.jpg

- Product of inflammation or mechanical strain
- May inhibit glottic closure




## Treatment

- Phoniatrician does the assessment and speech and language therapist the rehabilitation
- Voice therapy
  - Primary treatment with FVD
  - Patient education, counselling, voice rest, voice therapy
- Physiotherapeutic methods (used with MTD)
  - Laryngeal massage, neck and shoulder girdle massage, streching
- Medical treatments
  - Medication, steroid injections, surgeries

## Info for the exercises

- Exercises used in this for the following video are: semi-occlusion with straw and pitch gliding
- Semi-occlusion=reduction of vocal tract where supraglottal pressure is used more compared to transglottal pressure
- Pitch gliding=changing the volume of your voice
- After the exercises we train to raise our voices correctly!

## Video

## References


- The accurate list of the references from Theseus of the thesis: Voice ergonomics for Physiotherapy students – lecture material by Annika Luukko